# 1. INTRODUCTION

## A. GENERAL DESCRIPTION AND SCOPE

The Relativistic Heavy Ion Collider (RHIC) operates to study nuclear phenomena in heavy ion collisions. The Collider and Experimental Facilities are the major components within a complex of other existing accelerators and beam transfer equipment. This report only covers the Collider, experimental halls, U- W-, X- and Y-Lines. Figure 1-A-1 shows an aerial view of the overall facility. Figure 1-A-2 is a schematic representation of the overall facility.

The Collider consists of two beams circulating in opposite directions around a pair of superconducting magnet rings in a 3.8 kilometers circumference tunnel. The machine is designed to collide the beams at six locations where experiments can be carried out, although only four of these locations have been developed. The other two areas are sites for future expansion.

Each ring is capable of accepting either protons or a species of heavy ions up to gold; therefore, the Collider can contain experimental beams of protons, heavy ions or a combination. Protons are accelerated up to a final energy of 250 GeV and gold ions to 100 GeV per nucleon (GeV/u).

Heavy ions will originate in the Tandem Van de Graaf (TVG), while the source of protons is the 200 MeV linac. Particles then enter the Booster and then into the Alternating Gradient Synchrotron (AGS). Bunches of ions or protons will be extracted and transferred to each of the two Collider rings via the AGS-to-RHIC Transfer Line (AtR). After filling the rings, the particles are accelerated to full energy. Once at full energy, the beams coast around the rings in stable orbits for many hours. At the end of the useful life of the beams, they are kicked on to a heavily shielded beam stop and the cycle is repeated.

The Collider rings are laid out in six regular arcs connected by insertion regions where the beams are steered to the collision point. The main superconducting components of the magnet system are 288 arc dipoles, and 108 insertion dipoles, and 276 arc and 216 insertion quadrupoles. In addition to dipoles and quadrupoles, there is an array of smaller magnets consisting of 72 trim quadrupoles, 288 sextupoles, and 492 corrector magnets. These superconducting magnets are cooled to a temperature of <4.6 kelvin by circulating supercritical helium gas supplied from a 25 kW refrigerator. A list of major parameters and applicable Codes and Standards for the RHIC Complex are shown in Tables 1-A-1 and 1-A-2.

Design Criteria for Prompt Radiation were established to guide designers in the construction of passive shielding. Operational controls for prompt radiation will be in accordance with 10 CFR 835 and DOE O 5400.5 for protection of radiation workers and the public, respectively.

Two major detector facilities, STAR and PHENIX, have been constructed at the six and 8 o'clock locations, respectively. Smaller "AGS class" experiments have been installed at the 2 and 10 o'clock locations. Four and 12 o'clock remain for future development. If the undeveloped regions are subsequently used for experiments, large detectors shall be reported in a consistent manner as those contained in this report, while small experiments will be treated generically. The Collider beam stops are located in the Collider tunnel on either side of the 10 o'clock region.

Based upon the analysis provided in the RHIC Preliminary Safety Analysis, Environmental Analysis and the findings of the DOE Independent Safety Reviews on December 2-3, 1992 and February 18-20, 1998, the Secretarial Officer for the Office of Science designated the RHIC Complex as a Low Hazard Facility. A Low Hazard Facility is defined as having minimal onsite consequences and negligible offsite consequences. In general, the workers are exposed to hazards comparable to light industry. This Risk Assessment shows that all hazards are consistent with a Low Hazard Facility and have been adequately controlled. Both the BNL S&H Services Division and the RHIC Project have established environment safety and health policies, procedures and standards to assure worker and public safety.

**TABLE 1-A-1**
**Major Parameters for the Collider**

| | |
|---|---|
| Kinetic Energy, Injection-Top (each Beam), Au | 10.8-100 GeV/u |
| protons | 28.3-250 GeV |
| Design Intensity/Au | $5.7\times10^{10}$ ($2.3\times10^{11}$) ions |
| Design Intensity/p | $5.7\times10^{12}$ ($2.3\times10^{13}$) p |
| Number of bunches/ring | 57 |
| Number of Au-ions/bunch | $1\times10^{9}$ |
| Number of Protons/bunch | $1\times10^{11}$ |
| Luminosity, Au-Au @ 100 GeV/u & 10 h av. | ~$2\times10^{26}$ $cm^{-2}$ $sec^{-1}$ |
| p-p @ 250 GeV & 10 h av. | ~$1\times10^{31}$ $cm^{-2}$ $sec^{-1}$ |
| Operational lifetime Au | ~10 h |
| Circumference | 3833.845 m |
| Number of crossing points | 6 |
| Free space at crossing point | ±9 m |
| Number of dipoles (192/ring + 12 common) | 396 |
| Number of quadrupoles (276 arc + 126 insertion) | 492 |
| Dipole field @ 100 GeV/u, Au | 3.45 T |
| Cooldown time (thermal), entire system | ~10 days |
| Filling time (each ring) | <1 min |
| Beam stored energy | ~200 kJ |
| Acceleration time | 1 min |

( ) 4 times Design Intensity

**TABLE 1-A-2**

**RHIC Design Criteria, Codes and Standards**

| DATA SOURCE | APPLICATION |
|---|---|
| ASME Boiler and Pressure Vessel Code, Section VIII | Pressure Vessel Design, Fabrication and Testing |
| ANSI B31.1, Power Piping | Pressure Piping Design, Fabrication and Testing |
| ASME Code B31.3-1990, Chemical Plant and Petroleum Refinery Piping | Pressure Piping Design, Fabrication and Testing |
| ASME Boiler and Pressure Vessel Code, Section IX | Welding Procedures |
| Expansion Joint Manufacturers' Association (EJMA) Code | All Bellows and Expansion Joint Design |
| CGA S-1.3-1980, Pressure Relief Device Standards, Part 3-Compressed Gas Storage Containers | Gas and Liquid Storage Tank and Vessel Design and Relief Valve Standards |
| NFPA 101, Life Safety Code | Building exits, fire protection, etc. |
| Occupational, Safety, and Health Standard 29CFR1910 | Workplace Safety |
| NFPA 70, National Electric Code | Electric Power Wiring |
| BNL Operations and Maintenance Manual | DOE Order 5480.19, Conduct of Operations & DOE Order 4330.4A, Maintenance Management Program |
| BNL Environment Safety and Health Standards and RadCon Manual | BNL Requirements for ES&H and Operational Readiness Review |
| Cryogenic Safety RHIC OPM Section 5.5.2.1 | System Safety |
| Oxygen Deficiency Hazards (ODH) RHIC OPM Section 5.2.2.4.1 | ODH Classifications and Control Measures |
| DOE Order 5400.5 | Radiation Proection of the Public and the Environment |

| DATA SOURCE | APPLICATION |
|---|---|
| 10 CFR 835 | Occupational Radiation Protection |
| DOE Order 420.2 | Safety of Acceleration Facilities |
| RHIC OPM 5.1.5.0.1 | Supplemental Electrical Safety Standards |
| American National Stanndards<br>American Iron and Steel Institute<br>American Institute of Steel Construction<br>American Society for Testing and Materials<br>American Society for Non-Destructive Testing<br>American Society of Heating, Refrigerating and Air-Conditioning<br>American Society of Mechanical Engineers<br>American Welding Society<br>National Fire Protection Association | Components and Assemblies Throughout the Complex |


**Figure 1-A-1.** Aerial View of the RHIC Complex.

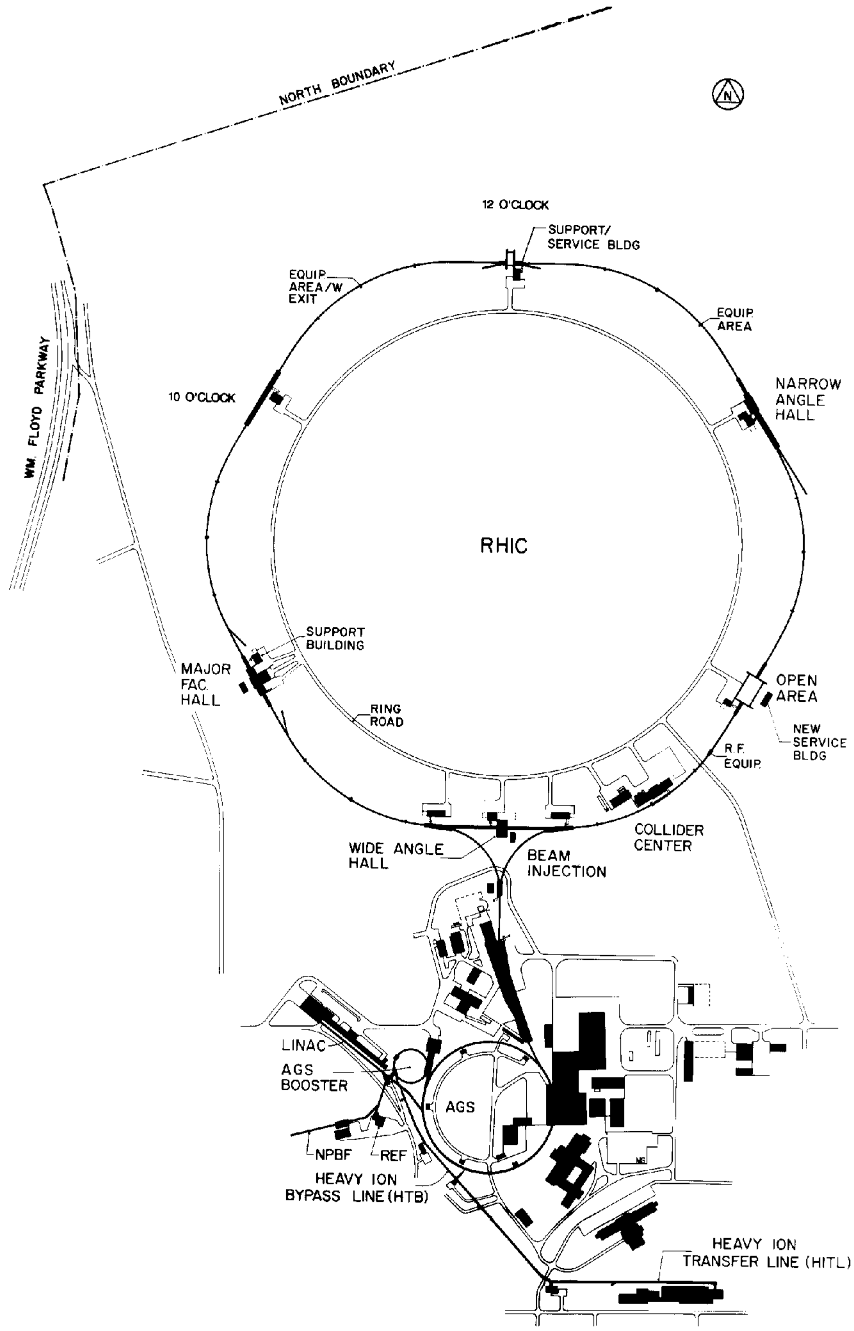


**Figure 1-A-2.** Schematic Representation of the RHIC Complex.